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Radio Frequency Ablation - The Magic treatment for Osteoid Osteoma

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Abstract

Osteoid osteoma is a relatively common benign bone tumour, always small in size (less than 2 cm) and painful. It occurs mainly in children and young adults. The basic radiological element is a distinctive small rounded area of osteolysis, the 'nidus', which consists of osteoid tissue surrounded by a halo of hyperostosis on radiographs or signal intensity on MRI.

MRI and Radio-isotope bone scanning always reveals a rounded area of intense increased uptake and dynamic-contrast CT can distinguish it from osteomyelitis.

The clinical feature of the lesion is local pain, typically more severe at night and often promptly responding to aspirin and other non-steroidal anti-inflammatory drugs. Other possible symptoms include growth disturbances, bony deformity, painful scoliosis, and if located within the capsule of a joint, swelling, synovitis, restricted movement, and contracture

In recent years, several CT-guided percutaneous techniques have been used in order to achieve removal or destruction of the nidus with minimal tissue invasion, including percutaneous trephine resection, drill resection with or without the subsequent injection of ethanol, thermal destruction by means of laser photocoagulation or RF ablation.

Materials and Methods: *We studied eight patients (n=8) of Osteoid Osteoma over a time frame of one year. Six cases were on the inner aspect of the thigh and one on the Tibia. CT scan was done at three month and 1 year interval on all the patients.*

Results: *All the cases (100%) showed excellent pain relief right from Day1. CT scan was done at three month and 1 year interval on all the patients. 7/8 (88%) showed complete resolution of the nidus in three months and 8/8 showed complete resolution at 1 year. Lesions of the cortical bone with intense reactive bone surrounding the nidus showed a greater tendency to ossify than those in subperiosteal or intramedullary locations. No biomechanical weakening caused by resorption of heated bone was seen. There were 0% complications and 0% recurrence.*

Summary: *The main challenge in CT-guided RF ablation, as in other percutaneous techniques with a lack of histological verification, is not the procedure itself.*

CT-guided percutaneous RF ablation is a simple minimally invasive, safe and effective technique for the treatment of osteoid osteomas and can be regarded as the treatment of choice for most cases

Open surgery should be reserved for cases of diagnostic uncertainty, as well as for spinal lesions into which heat cannot be introduced without the risk of neurological damage.

Keywords: *Radiofrequency ablation, Osteoid Osteoma, Nidus*

INTRODUCTION

Osteoid osteoma is a relatively common benign bone tumour, always small in size (less than 2 cm) and painful. It occurs mainly in children and young adults. The basic radiological element is a distinctive small rounded area of osteolysis, the 'nidus', which consists of osteoid tissue surrounded by a halo of hyperostosis on radiographs or signal intensity on MRI.

MRI and Radio-isotope bone scanning always reveals a rounded area of intense increased uptake and dynamic-contrast CT can distinguish it from osteomyelitis.

The clinical feature of the lesion is local pain, typically more severe at night and often promptly responding to aspirin and other non-steroidal anti-inflammatory drugs. Other possible symptoms include growth disturbances, bony deformity, painful scoliosis, and if located within the capsule of a joint, swelling, synovitis, restricted movement, and contracture

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The sources of Thermal Ablation are as follows

- Microwave
- High intensity ultrasound
- Laser
- RFA
- Injection of heated fluids (saline, ethanol, contrast)

The effects of heat on living cells at different temperatures are as follows

42 ° C cells die but it may take a significant amount of time (approximately 60 min).

42 - 45 ° cells are more susceptible to damage by radiation & chemo.

46 - 60 ° irreversible cellular damage occurs depending upon duration of exposure.

50 – 52 ° cellular death in 4 – 6 minutes.

However Temperatures >105 degrees cause boiling, vaporization and carbonization, all of which decrease energy transmission and consequently impede ablation. Hence the temperature of Radio frequency ablation must be kept to below 105 degrees Celsius.

The benefits of Radio Frequency Ablation are manifold of which few are

- Imaging guidance
- Tumour ablation in non-surgical candidates
- Reduced morbidity
- Outpatient procedure

The radiofrequency needle electrode (14 -18 ga) is introduced into the lesion

An electrical circuit is set up between the un-insulated needle tip and the grounding pads on the thighs or legs

Figure 1. The Needle Electrode used. (Multiple tines)

Figure 2: A grounding Pad used for insulation

Two types of needle electrodes exist, the single electrode and those with multiple tines.

Three units are commercially available (approved by the FDA):

1. Radionics (Radionics Inc., Burlington MA)
2. RITA Medical Systems (Mountain View CA) (multiple tines)
3. Le Veen (Radiotherapeutics Mountain View, CA) (multiple tines)

Radionics (cool-tip) probe (needle) is available in one size 17 Ga and 10, 15 and 25 cm lengths. It is a single or cluster electrode with a tip exposure of 2 – 4 cm. This is an internally cooled device that also uses pulsing sequences to improve heating.

Figure 3: A Radionics Machine [1]

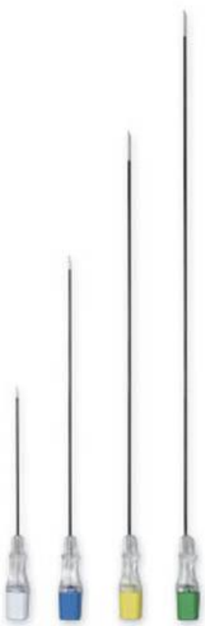

Figure 4: Tip of Radionic probe.

The RITA (radiofrequency interstitial tumor ablation) probe is a 15 ga, with various types of arrays.

It uses temperature of tissue to monitor its effect. The tines have a thermocouple at the tip that registers the temperature of the heated tissue.

Figure 5: RITA machine [2]

The Le Veen Probe

This needle has multiple (10, 12) tines. There are 2.0, 3.0, 3.5 and 4.0 cm diameter needles. It relies on impedance feedback. Radionics and RITA allow for heating of the tract whereas Radio therapeutics must have the tines deployed to heat.

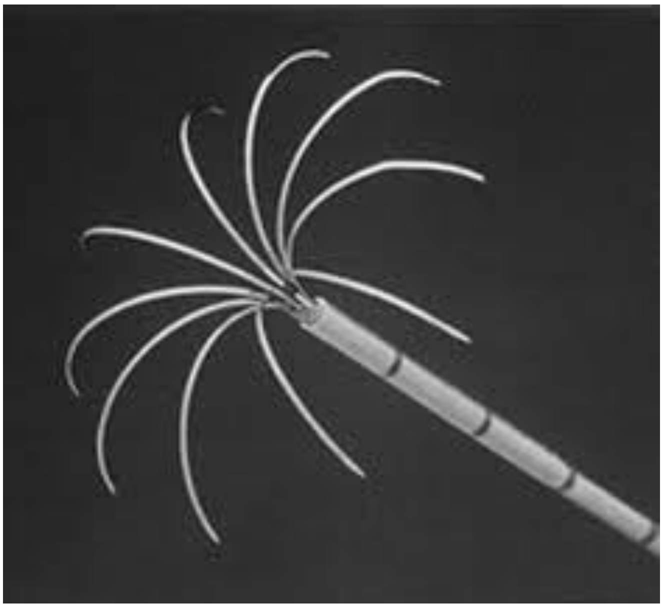

Figure 6: The Le Veen Probe [3]

Methods to increase the area of coagulation necrosis:

- Multiple punctures with several electrodes. This is time consuming and associated with increased complications.
- Bipolar electrodes
  2 electrodes spaced approximately 4 cm apart. The problem is that the coagulation necrosis is elliptical and not wide in the centre. This shape is unlike most tumours and is not practical.
- Multiple array needles (hooked arrays or tines):
  They increase the volume of coagulation necrosis.
- Internally cooled electrodes:
  This electrode is closed and has 2 lumens. One lumen receives chilled perfusate and the other removes the warmed perfusate. This keeps the area adjacent to the needle cooled and prevents charring and vaporization.
- Saline-enhanced RFA
  The injection of heated saline can cause better dissemination of heat than a solid tumour.
- Pulsing with alternating high and low energy
  Pulsing with alternating high and low energy may increase the area of ablation. The area around the electrode preferentially cools more in-between pulses and greater energy can be applied affecting the surrounding tissue. Pulsing and internally cooled needles are synergistic.
- Decreasing vascular flow
  Local or adjacent blood flow may create a heat sink and cause cooling and dissipation of heat. This is called "perfusion mediated cooling". Vessels > 3 mm can impede or prevent complete ablation. An attempt to limit this can be performed surgically with the "Pringle" manoeuvre or percutaneously by embolization.
- Improved tissue heat conduction
  Besides saline, other agents can also improve heat conduction or sensitize the tissue to heat creating a larger area of coagulation necrosis
- Thermo sensitizers
  Thermo sensitizers reduce the temperature at which coagulation necrosis occurs. Known thermo sensitizers include hypoxia (embolization), chemotherapy.

Materials and Methods

We studied eight patients (n=8) of Osteoid Osteoma over a time frame of one year. Six cases were on the inner aspect of the thigh and one on the Tibia. CT scan was done at three month and 1 year interval on all the patients.

No.	Age/Sex	Location of tumour	Pain relief	Resolution of the Nidus
1	12/M	Neck of Femur	Day1	2 months
2	7/F	Medial femoral Condyle	Day1	1month
3	13/M	Neck of Femur	Day1	3 months
4	11/M	Posterior Tibial Cortex	Day1	10 months
5	10/M	Neck of Femur	Day1	2 months
6	9/F	Neck of Femur	Day1	1.5 month
7	12/F	Anterolateral Tibial Cortex	Day1	3 months
8	10/M	Neck of Femur	Day1	3 months

Procedure details:

The procedure of Radio frequency ablation is always done in a CT suite. It needs the help of an interventional radiologist. The procedure is quite radio intensive and needs plenty of CT scan shoots before the osteoid osteoma can be precisely ablated.

Precautions

Pre-operatively skin marking must be done and a guide wire must be inserted on the skin marking area. This prevents inaccurate probe placement and multiple entry points.

All of this must be done under CT scan guidance. This entails that after each positioning the operating surgeon, anesthetist and the radiologist leave the room whenever a new CT scan image is obtained. This protects them from radiation.

The anaesthesia used is generally a short general anaesthesia. However a local anesthesia with sedation can be used. We prefer a short general anaesthesia. If local anaesthesia is used, precaution must be used that the anaesthetic agent spreads to the deeper tissues.

Appropriate protection must be offered to the Gonads and the vital organs of the patient to prevent the hazards of radiation overdose.

The tines of the radiofrequency probe must be opened only after successfully reaching the tumour area, otherwise this lead to disastrous ablation of the surrounding normal tissue.

The temperature of the ablation mustn't exceed 95 degrees Celsius. Else this will cause thermal necrosis of the surrounding tissue.

And of course the proof of the pudding is an immediate pain relief, which is appreciable on the same day. The procedure by itself is a day care procedure and the patient can be sent home the same day itself after administering some mild painkillers.

Drawbacks of radiofrequency ablation

The main drawback of radiofrequency ablation is the COST. This is partly due to the fact that the probe has to be ideally changed after every surgery. And even if re-used the probe cannot be successfully used for more than ten surgeries. Also the equipment cost and the cost of the CT scan suite adds to the total.

Secondly a sterile environment must be maintained. Although rare but infection must be kept in mind as it is a semi-invasive procedure.

Lastly the amount of radiation. On an average at least 40-50 shoots of CT scan are taken depending on expertise.

Results

All the cases (100%) showed excellent pain relief right from Day1. CT scan was done at three month and 1 year interval on all the patients. 7/8 (88%) showed complete resolution of the nidus in three months and 8/8 showed complete resolution at 1 year. Lesions of the cortical bone with intense reactive bone surrounding the nidus showed a greater tendency to ossify than those in subperiosteal or intramedullary locations. No biomechanical weakening caused by resorption of heated bone was seen. There were 0% complications and 0% recurrence.

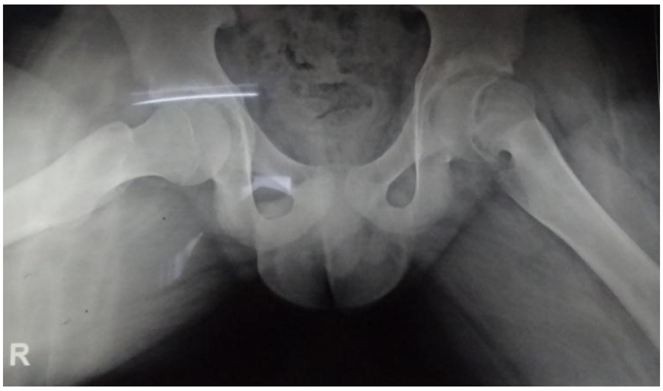

Figure 7: A 12 year old boy presented with pain on the inner aspect of the thigh.

Figure 8: A Scale was used to measure the distance of the lesion pre-operatively from the groin

Figure 9. The pre-op CT scan cross section showing the nidus on the inner aspect of thigh

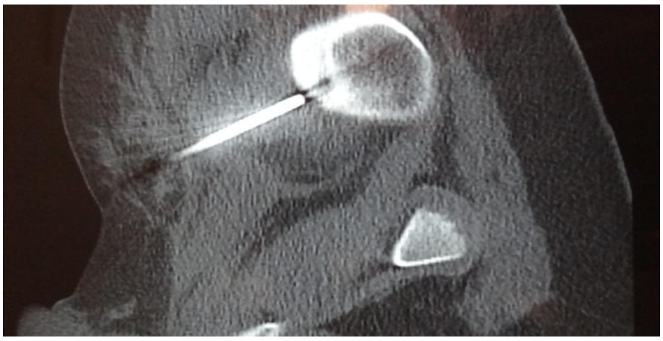

Figure 10. The probe as seen on CT scan

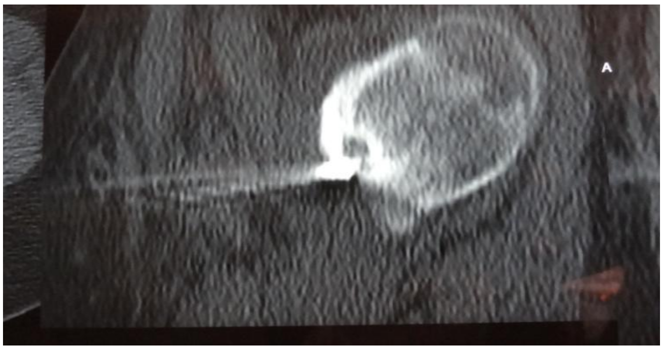

Figure 11. The probe is accurately placed in the lesion

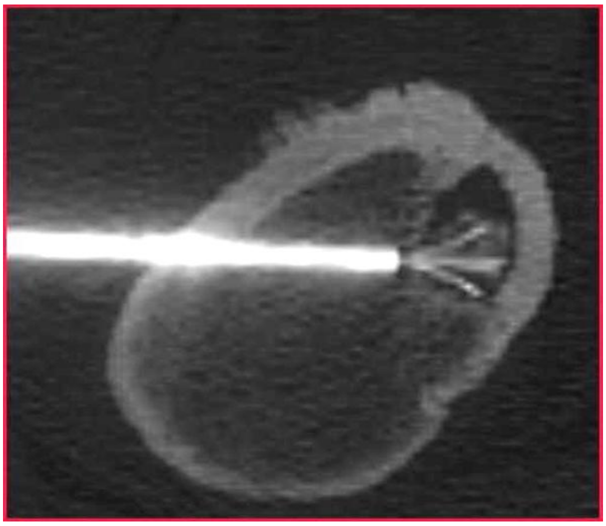

Figure 12: Opening up the Tines for a wider spread effect

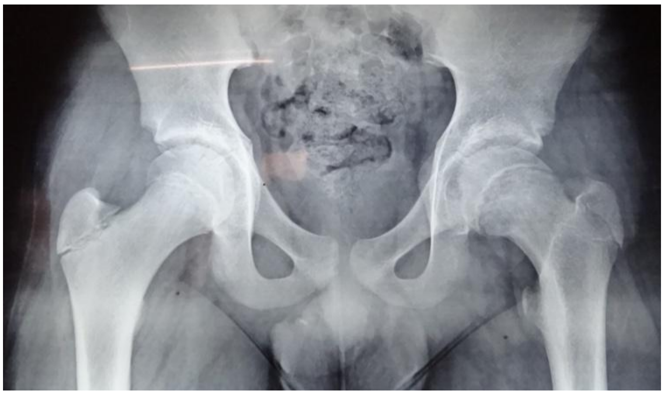

Figure 12. A follow up X-ray of the same boy 3 months later

DISCUSSION

Early diagnosis enables timely treatment, avoids unnecessary pain and treatments, and minimizes morbidity, including bone deformity [5]

Some bone lesions are reported to mimic osteoid osteoma like bone infarct, chronic osteomyelitis, and chondroblastoma.[6]. The diagnosis of osteoid osteoma is based on a combination of history, clinical examination, and radiological data. [7]

INDICATIONS FOR RFA

- Cardiac conduction abnormalities
- Trigeminal neuralgia (hyperactive neurologic foci)
- Bone neoplasms –osteoid osteomas and metastasis
- Liver neoplasms – primary and metastatic
- Renal cell carcinoma for patients requiring nephron-sparing procedure
- Other neoplasms including lung, breast, spleen, prostate, pheochromocytomas, adrenal gland, sarcomas, head and neck tumours, cerebral metastasis and neuroendocrine tumours.
- Although not common, it is sometimes used for palliation

CONTRAINDICATIONS FOR RFA

- Active infection
- Pregnancy
- Coagulopathy +/-
- Lesions at the liver hilum (peri-hilar region) +/-

- HCC patients with Child-Pugh C do not benefit from RFA as far as survival
- Subcapsular lesions may hurt more and predispose to tumour seeding
- Lesions within 1 cm from the skin when ablated can result in a skin burn
- Extrahepatic disease unless the metastasis are more likely to cause mortality than the extrahepatic disease

COMPLICATIONS OF RFA

- Overall – 2 - 12% [4]
- Major - 5-10% (Mortality - 0.2%, Morbidity 1.7%)
- Most common are focal pain, pleural effusion and regional haemorrhage.
- Pain - the patient commonly only experiences pain in the first 24 hours.
- Bleeding – intraperitoneal, subcapsular, intrahepatic (may be observed in up to 30%)
- Diaphragm necrosis
- Pleural effusion
- Fever
- Infection, Abscess
- Portal thrombosis
- Bile duct, Biloma
- Thermal damage to adjacent organs e.g. cholecystitis and colonic burn
- Grounding pad burns
- Tumour seeding - may occur either due to the larger needles or the release of tumour cells associated with intratumoral explosion resulting from an increase in temperature.

Characteristic radiograph findings include a nidus of vascular osteoid tissue in the bone cortex surrounded by reactive sclerotic bone. However, CT is the modality of choice for detecting this tumor and providing the best characterization of the nidus and the surrounding sclerotic bone. [8] Magnetic resonance imaging is not as specific as CT [9,10,11, 12] Radionuclide scintigraphy discloses intense activity at the nidus and decreased activity in the surrounding reactive zone. [13]. Although endowed with low specificity, it may be useful for lesion localization due to its high sensitivity, particularly when radiographs are normal or nearly normal. In the current study, radionuclide scintigraphy was positive in all patients.

Complete surgical excision of the nidus is curative and provides symptom relief. Open surgery is the treatment of choice despite its drawbacks, such as difficulty locating the lesion intraoperatively, the need for prolonged length of hospital stay, and the possibility of postoperative complications that range from an unsatisfactory cosmetic result to bone fracture because lesion resection may leave a defect that is vulnerable to fracture. Some patients require internal fixation and bone grafts. Precise intraoperative localization of the lesion is difficult even with intraoperative scintigraphy or needle- or wire-based methods. Furthermore, a second procedure may be required when resection is incomplete. Lesions may be located at sites that prevent surgical excision due to the risk of damaging the adjacent structures. The excision of articular and epiphyseal lesions may involve arthrotomy and impair bone growth or joint mobility in these often young patients. Average postoperative length of hospital stay is 3 to 5 days, and activity is often restricted for 1 to 6 months [14, 15].

Figure 13. Demonstrating how the probe is placed

Figure 14. The RITA probe that is used.

Computed tomography–guided percutaneous radiofrequency thermo ablation, which induces lesion necrosis, is minimally invasive, safe, effective, and repeatable, with reported success rates ranging from 80% to 100%. [8,15] Although expensive, its cost is significantly lower than that of traditional open surgery due to reduced hospital stay and less need of repeated surgery. [16]. The potential complications of percutaneous radiofrequency thermo ablation are cellulitis, [17] bleeding and infection at the skin entry site, intraoperative vasomotor instability [18] and clubfoot due to temporary muscle contraction. Extreme caution must be exercised when operating on lesions less than 1 cm from structures such as nerves and vessels or on superficial lesions that are at risk for soft tissue damage and burns from thermal necrosis. The percutaneous radiofrequency thermo ablation settings reported in previous reports are 4 minutes at 90°C or 6 minutes at 80°C.The current authors applied a prolonged ablation time of 5 minutes at 90°C. [19]

In the literature, follow-up CT scans and magnetic resonance imaging showed decreased nidus size and perilesional edema with a periosteal reaction. However, no radiological changes were observed in some patients despite the clinical remission. Therefore, radiological healing does not coincide with a favorable clinical outcome. Imaging follow-ups do not determine the success or failure of radiofrequency treatment. The main disadvantage of percutaneous radiofrequency thermo ablation is the frequent absence of histological confirmation of the diagnosis due to insufficient biopsy tissue; however, tissue obtained during open surgery does not always allow a definitive diagnosis to be made.

However, in a previous study, osteoid osteoma was confirmed in 36% to 100% of bone biopsies before percutaneous radiofrequency thermo ablation was performed. Some authors reported that the diagnosis of osteoid osteoma is mainly clinical and radiological and do not regularly perform biopsies before percutaneous radiofrequency thermoablation. Others perform tissue sampling preoperatively. Histopathological confirmation of the diagnosis may help, especially when the treatment failed or the disease recurred. However, the diagnosis of osteoid osteoma is considered to be based on clinical and radiological features and postoperative symptom regression. [18]

REVIEW OF LITERATURE

Jhankaria et al evaluated 40 patients in whom RFA was performed for osteoid osteomas between October 2005 and February 2008. The lesions were located in the femur (n = 22), tibia (n = 10), humerus (n = 2), acetabulum (n = 2), radius (n = 1), fibula (n = 1), patella (n = 1), and calcaneum (n = 1). All patients had a pain relief in48hours. Two patients (5% of cases) had recurrence of pain after intervals of 5 and 8 months, respectively, following the ablation; this was due to recurrence of the lesion. Complete pain relief was however achieved after a second ablation in both cases. [20]

Hoffmann et al in another study treated Within 61 months 39 patients (23 male, 16 female, 7–53 years, mean 18.7 years, median 17 years) suffering from osteoid osteoma.. Lesions were located in femur (n = 20), tibia (n = 10), spine (n = 5), humerus (n = 1), radius (n = 1), talus (n = 1) and pelvis (n = 1). In children, RFA was performed under general anaesthesia, in adults conscious sedation was preferred. In 29 of 39 (74%) lesion biopsies were obtained. Cooling of skin was performed in OOs located in bones with minor soft tissue covering (tibia, radius) and saline flushing via an additional needle was performed if the OO was adjacent to nerve structures. Primary success rate, complications, symptom-free interval, follow-up and biopsy results were evaluated.

His results were within observation period (1–61 months; median: 32 months) 38 of 39 patients were successfully treated and had no more complaints. In 3 of 38 patients relapse occurred after 1, 14 and 32 months and RFA was repeated. Two major complications (broken drill, infection) and 2 minor complications (hematoma, prolonged pain) were observed. Biopsy was able to prove diagnosis in 14 of 29 (48%) cases. [21]

De Palma and colleagues studied twenty patients of Radiofrequency ablation. Mean follow-up was 44 months (range, 3–106 months). Pain relief was significant in 95% of patients; it disappeared within 24 hours in 14 patients, within 3 days in 4, and within 7 days in 1. The patient with persistent symptoms underwent another percutaneous radiofrequency thermo ablation procedure that was successful. The difference between pre- and postoperative pain was significant (P <.01). No recurrences occurred. [22]

SUMMARY

The main challenge in CT-guided RF ablation, as in other percutaneous techniques with a lack of histological verification, is not the procedure itself. Radiation exposure is one and cost is another limiting factor.

CT-guided percutaneous RF ablation is a simple minimally invasive, safe and effective technique for the treatment of osteoid osteomas and can be regarded as the treatment of choice for most cases.

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Author Profile

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